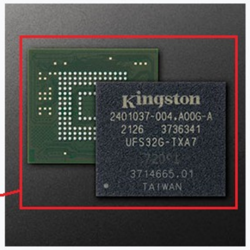
Exhibit 2

Method Claim: 1

<table>
<tr><th>US10095426</th><th>Kingston UFS256-CY14 UFS 3.1 Flash Storage (“The accused product”)</th></tr>
<tr><td>1. A method of storing data on a storage system comprising:</td><td>
The accused product discloses a method of storing data on a storage system (e.g., the accused product).
As shown below, the accused product is a storage system based on UFS 3.1. The accused product is used by a host such as smartphone, to store data in compliance with the UFS 3.1 specification.
Kingston Technology Products Solutions Support Company Blog
UFS – High performance storage for mobile and embedded applications
Kingston's Universal Flash Storage (UFS) is an ideal storage solution for applications that require high performance and low power in a single integrated package. The small form factor and low power consumption make UFS ideal for embedded and mobile applications. UFS is an open standard developed by the Joint Electronic Device Engineering Council (JEDEC). Compliance with this standard ensures compatibility with a large selection of host processors. Kingston's UFS devices integrate NAND flash non-volatile memory with Kingston's UFS controller in a single surface-mounted packaged device. Kingston's advanced UFS controller provides all the algorithms necessary to reliably manage the NAND flash memory while fully implementing the UFS functionality and features.
Request Information
storage system


https://www.kingston.com/en/embedded/ufs-embedded-flash
UFS part numbers and specifications
<table>
<tr><th>Part number</th><th>Capacity</th><th>Description</th><th>Package</th><th>Operating temperature</th></tr>
<tr><td>UFS32G-TXA7</td><td>32GB</td><td>UFS 2.1 G4 2L 153B 32GB</td><td>11.5x13x0.85</td><td>-25°C ~ +85°C</td></tr>
<tr><td>UFS64G-TXA7</td><td>64GB</td><td>UFS 2.1 G4 2L 153B 64GB</td><td>11.5x13x0.85</td><td>-25°C ~ +85°C</td></tr>
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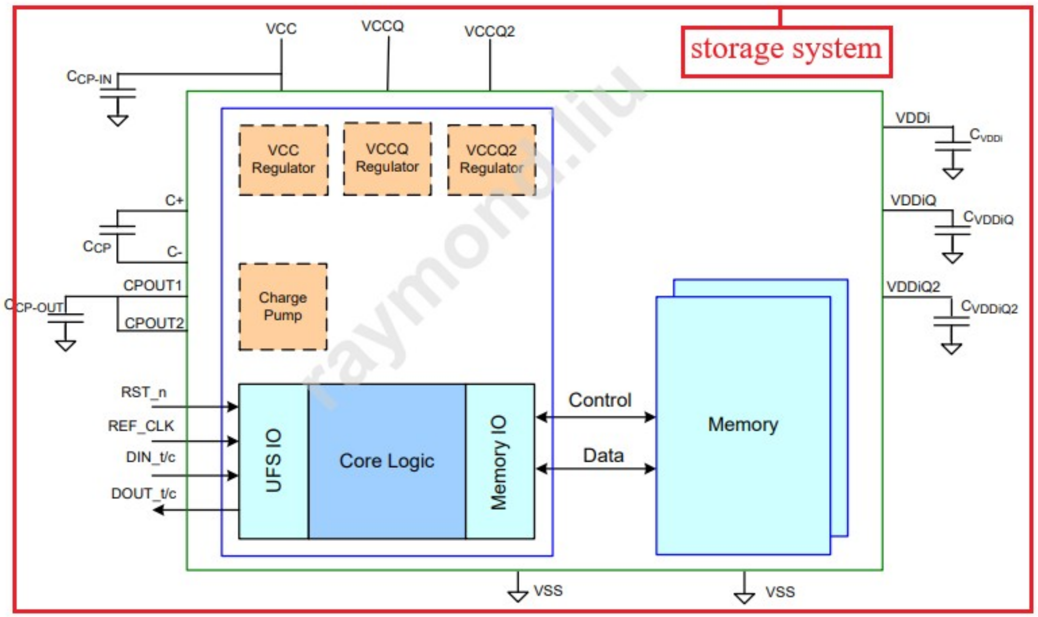
</table>
https://www.kingston.com/en/embedded/ufs-embedded-flash
</td></tr>
</table>

	UNIVERSAL FLASH STORAGE (UFS), VERSION 3.1 (From JEDEC Board Ballot JCB-19-31, formulated under the cognizance of the JC-64.1 Subcommittee on Electrical Specifications and Command Protocols, Item 135.99) **1 Scope** This standard specifies the characteristics of the UFS electrical interface and the memory device. Such characteristics include (among others) low power consumption, high data throughput, low electromagnetic interference and optimization for mass memory subsystem efficiency. The UFS electrical interface is based on an advanced differential interface by MIPI M-PHY specification which together with the MIPI UniPro specification forms the interconnect of the UFS interface. The architectural model is referencing the INCITS T10 (SCSI) SAM standard and the command protocol is based on INCITS T10 (SCSI) SPC and SBC standards. Source: JESD220E specification

6.1 UFS Signals

Figure 6.1 represents a conceptual drawing of UFS device. Utilization of internal regulators and connection of those to different parts of the sub-system may differ per implementation.



Source: JESD220E specification

	Foreword This standard has been prepared by JEDEC. The purpose of this standard is definition of a UFS Universal Flash Storage electrical interface and a UFS memory device. This standard defines a unique UFS feature set and includes the feature set of eMMC standard as a subset. This standard references several other standard specifications by MIPI (M-PHY and UniPro specifications) and INCITS T10 (SBC, SPC and SAM draft standards) organizations. **Introduction** The UFS electrical interface is a universal serial communication bus which can be utilized for different types of applications. It's based on MIPI M-PHY specification as physical layer for optimized performance and power. The UFS architectural model references the INCITS T10 SAM model for ease of adoption. The UFS device is a universal data storage and communication media. It is designed to cover a wide area of applications as smart phones, cameras, organizers, PDAs, digital recorders, MP3 players, internet tablets, electronic toys, etc. storing data on a storage system Source: JESD220E specification

<table>
<tr>
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5.2 UFS System Model

Figure 5.4 shows an example of UFS system. It shows how a UFS host is connected to a UFS device, the position of UFS host controller and its related UFS HCI interface.

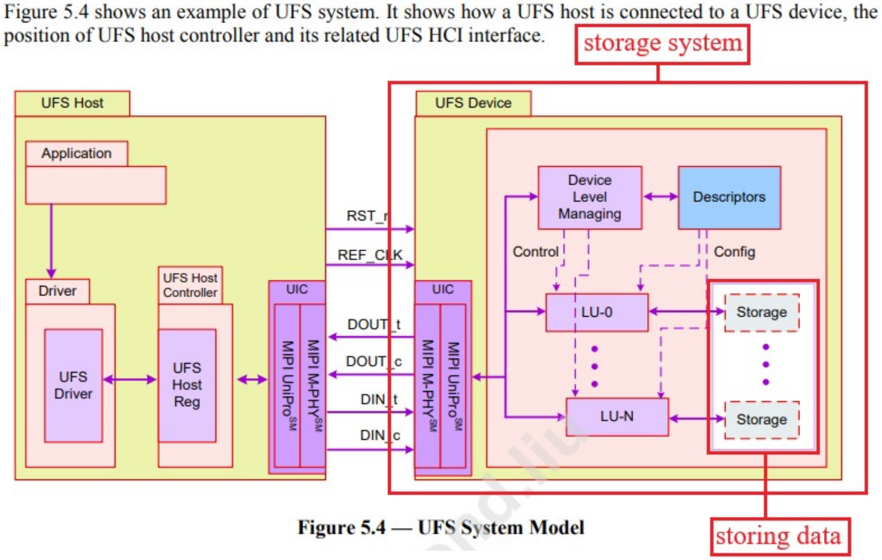


Figure 5.4 — UFS System Model

Source: JESD220E specification

</td>
</tr>
<tr>
<td>providing a storage medium as part of the storage system;</td>
<td>

The accused product discloses, providing a storage medium (e.g., NAND flash) as part of the storage system (e.g., the accused product).

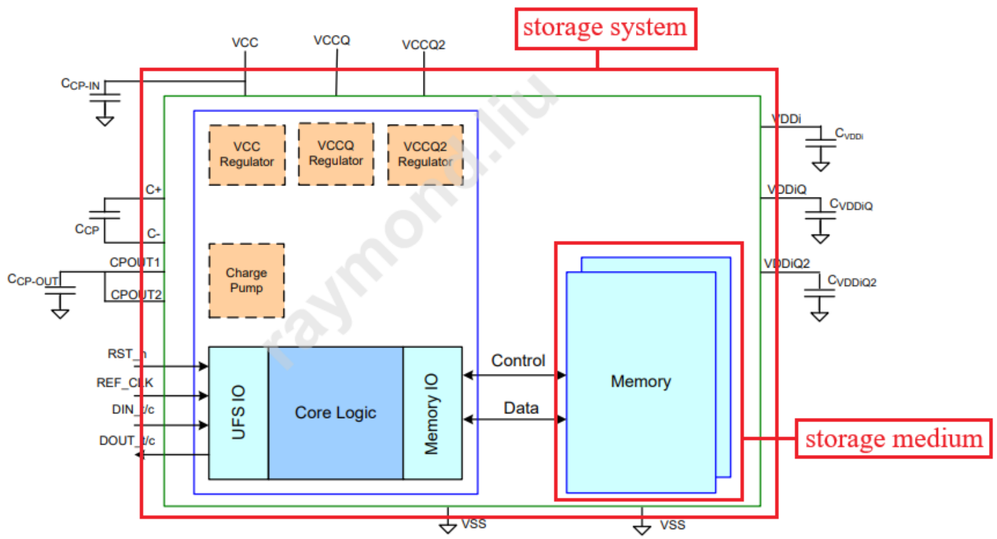
As shown below, the accused product is a storage system based on UFS 3.1. It uses NAND flash as the storage medium.

UFS part numbers and specifications

Part number	Capacity	Description	Package	Operating temperature
UFS32G-TXA7	32GB	UFS 2.1 G4 2L 153B 32GB	11.5x13x0.85	-25°C ~ +85°C
UFS64G-TXA7	64GB	UFS 2.1 G4 2L 153B 64GB	11.5x13x0.85	-25°C ~ +85°C
UFS256-CY14	256GB	UFS 3.1 G4 4P TLC 153B 256GB	11x13x0.95	-25°C ~ +85°C

https://www.kingston.com/en/embedded/ufs-embedded-flash

</td>
</tr>
</table>

	What is UFS 3.1 and how does it work? Author: icDirectory · Date: June 24, 2024 15:06:29 Universal Flash Storage (UFS) 3.1 is a high-performance storage technology designed for mobile devices, such as smartphones and tablets, but it can also be used in other applications like laptops, digital cameras, and automotive systems. UFS 3.1 builds upon the capabilities of its predecessor, UFS 3.0, offering improvements in speed, power efficiency, and overall performance. Here's a detailed look at what UFS 3.1 is, how it works, and the key features it brings to the table: ### Architecture and Components **1. NAND Flash Memory:** **- UFS 3.1 utilizes NAND flash memory, which is a type of non-volatile storage that retains data even when the device is powered off. NAND flash memory is known for its high density, fast read/write speeds, and durability.** https://www.icdirectory.com/blog/what-is-ufs-3-1-and-how-does-it-work-41004339.html  Source: JESD220E specification

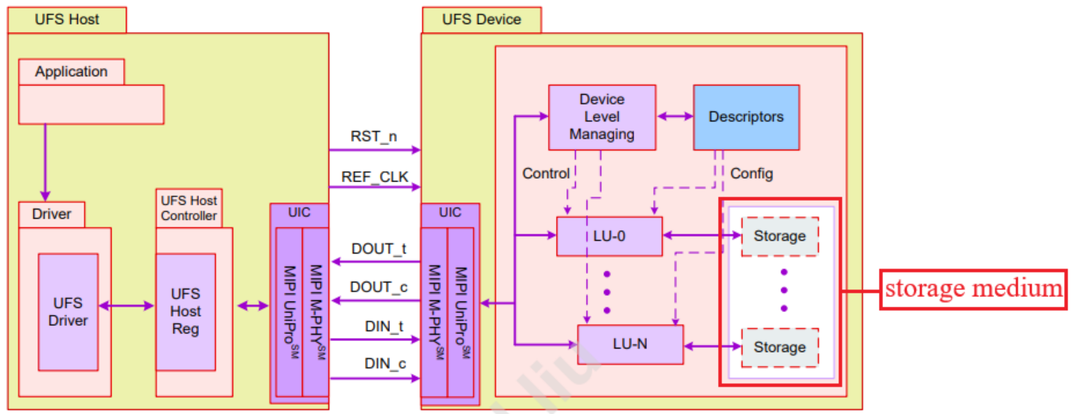


Figure 5.4 — UFS System Model

Source: JESD220E specification

13.4.17 WriteBooster

13.4.17.1 Overview

The write performance of TLC NAND is considerably lower than SLC NAND because the logically defined TLC bits require more programming steps and have higher error correction probability. To improve the write performance, part of the TLC NAND (normal storage) is configured as SLC NAND and used as write buffer, temporarily or permanently. Using SLC NAND as a WriteBooster Buffer enables the write request to be processed with lower latency and improves the overall write performance. Some portions of TLC NAND allocated for the user area are assigned as the WriteBooster Buffer. The data written in the WriteBooster Buffer can be flushed into TLC NAND storage by an explicit host command or implicitly while in hibernate (HIBERN8) state. Technologies other than TLC and SLC NAND may be used as normal storage and WriteBooster Buffer.

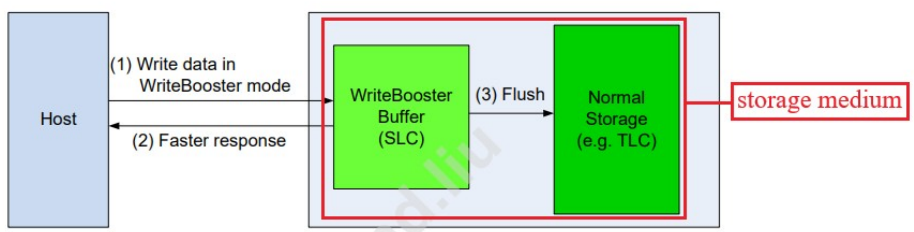
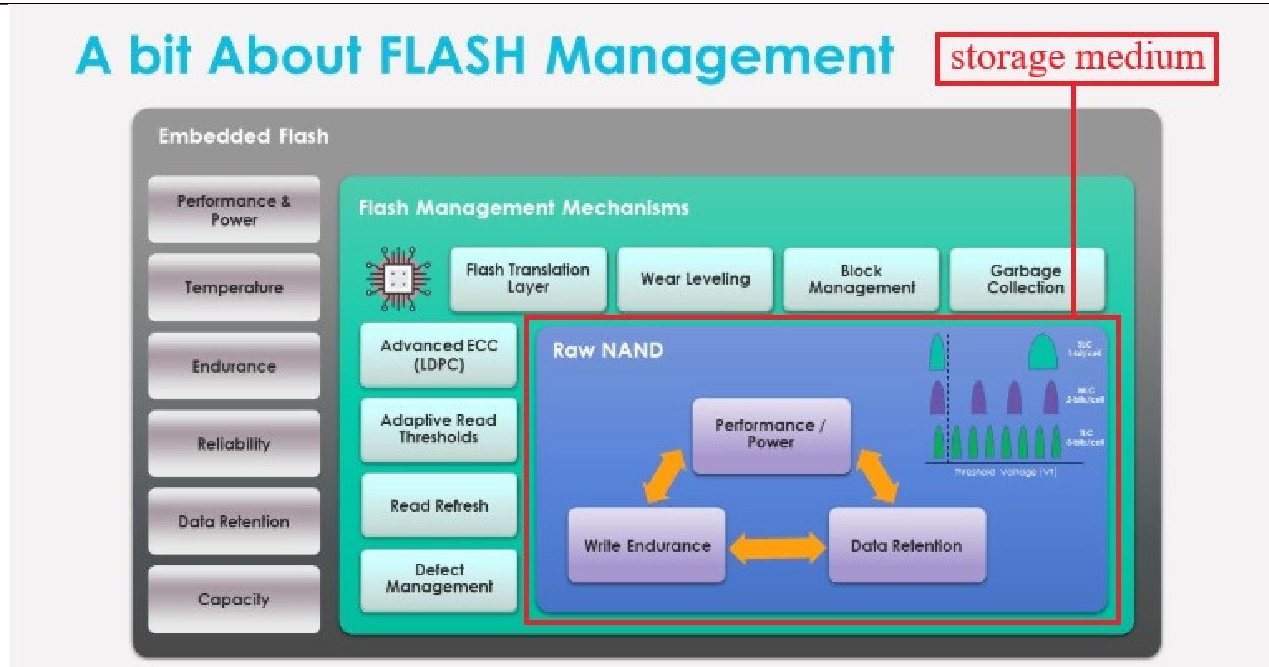
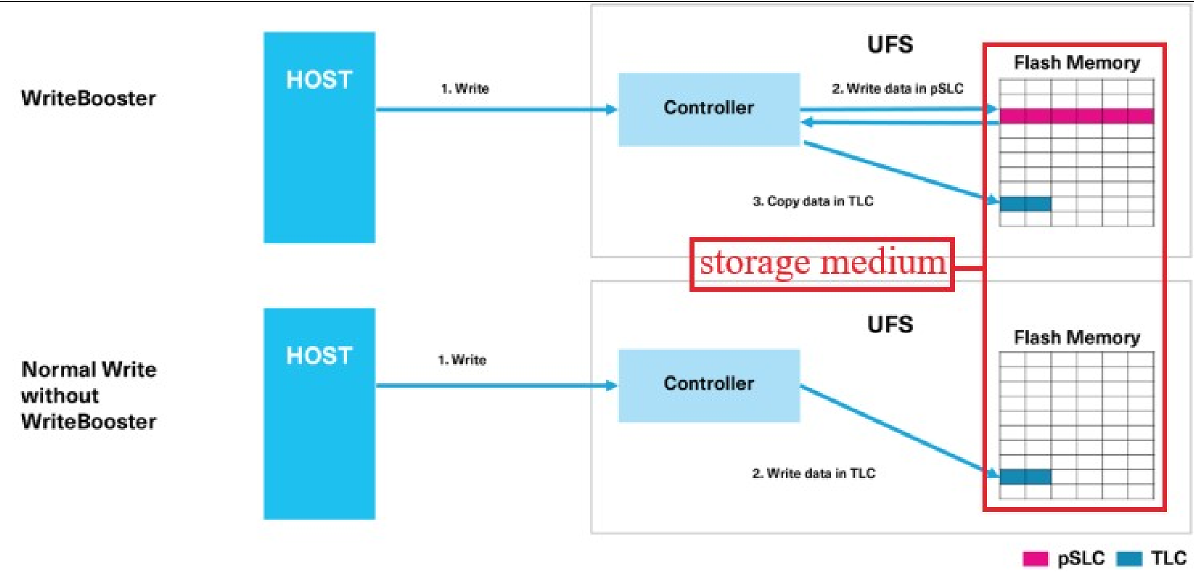


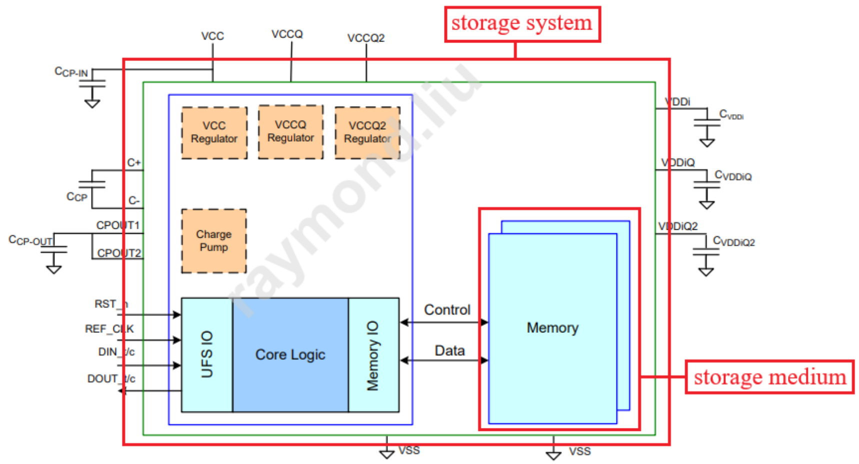
Figure 13.7 — Concept of WriteBooster feature

Source: JESD220E specification

	 *Figure 3. Flash memory needs management to optimize its characteristics.* https://www.5gtechnologyworld.com/six-design-considerations-for-local-data-storage/

	 https://americas.kioxia.com/content/dam/kioxia/en-us/business/memory/mlc-nand/asset/KIOXIA_WriteBooster_Feature_Tech_Brief.pdf
storing general purpose data on the storage medium using a first physical storage format attribute; and	The accused product discloses storing general purpose data (e.g., low-volume, non-critical data) on the storage medium (e.g., NAND flash) using a first physical storage format attribute (e.g., memory blocks configured as multi-bit per cell such as TLC, QLC or more). As shown below, the accused product is a storage system based on UFS 3.1. UFS 3.1 devices use multi-bit-per-cell technologies (TLC, QLC, and others) as the storage medium (NAND flash). Data from the host is written to the storage medium using Logical Units (LUs), each having memory blocks mapped to it. The UFS 3.1 specification includes a 'WriteBooster' feature, which creates an SLC buffer from TLC/QLC blocks. For time-critical and high-speed tasks, LUs mapped to the SLC buffer are used, whereas for low-volume, non-critical operations, such as saving data in the background, LUs mapped to the TLC/QLC blocks are used.

	UFS part numbers and specifications Part number | Capacity | Description | Package | Operating temperature UFS32G-TXA7 | 32GB | UFS 2.1 G4 2L 153B 32GB | 11.5x13x0.85 | -25°C ~ +85°C UFS64G-TXA7 | 64GB | UFS 2.1 G4 2L 153B 64GB | 11.5x13x0.85 | -25°C ~ +85°C UFS256-CY14 | 256GB | UFS 3.1 G4 4P TLC 153B 256GB | 11x13x0.95 | -25°C ~ +85°C https://www.kingston.com/en/embedded/ufs-embedded-flash **What is UFS 3.1 and how does it work?** Author: icDirectory · Date: June 24, 2024 15:06:29 Universal Flash Storage (UFS) 3.1 is a high-performance storage technology designed for mobile devices, such as smartphones and tablets, but it can also be used in other applications like laptops, digital cameras, and automotive systems. UFS 3.1 builds upon the capabilities of its predecessor, UFS 3.0, offering improvements in speed, power efficiency, and overall performance. Here's a detailed look at what UFS 3.1 is, how it works, and the key features it brings to the table: ### Architecture and Components **1. NAND Flash Memory:** **- UFS 3.1 utilizes NAND flash memory, which is a type of non-volatile storage that retains data even when the device is powered off. NAND flash memory is known for its high density, fast read/write speeds, and durability.** https://www.icdirectory.com/blog/what-is-ufs-3-1-and-how-does-it-work-41004339.html



Source: JESD220E specification

UFS Logical Units

UFS flash device is composed of memory blocks that are mapped to different Logical Units (LUs). UFS device address space is organized in several memory areas configurable by the user. In particular, such memory areas are denoted as logical units and characterized by the fact that they have independent logical addressable spaces starting from the logical address zero. Thus, a logical unit (LU) is an externally addressable, independent, processing entity that processes SCSI tasks (commands) and performs task management functions. Each logical unit is independent of other logical units in a device

https://software-dl.ti.com/processor-sdk-linux/esd/AM65X/07_00_01_06/exports/docs/linux/Foundational_Components/Kernel/Kernel_Drivers/UFS.html

Kilobyte: 1024 or 2^{10} bytes.

Logical Unit: A logical unit is an internal entity of a bus device that performs a certain function or addresses a particular space or configuration within a bus device.

Source: JESD220E specification

13.4.17 WriteBooster

13.4.17.1 Overview

The write performance of TLC NAND is considerably lower than SLC NAND because the logically defined TLC bits require more programming steps and have higher error correction probability. To improve the write performance, part of the TLC NAND (normal storage) is configured as SLC NAND and used as write buffer, temporarily or permanently. Using SLC NAND as a WriteBooster Buffer enables the write request to be processed with lower latency and improves the overall write performance. Some portions of TLC NAND allocated for the user area are assigned as the WriteBooster Buffer. The data written in the WriteBooster Buffer can be flushed into TLC NAND storage by an explicit host command or implicitly while in hibernate (HIBERN8) state. Technologies other than TLC and SLC NAND may be used as normal storage and WriteBooster Buffer.

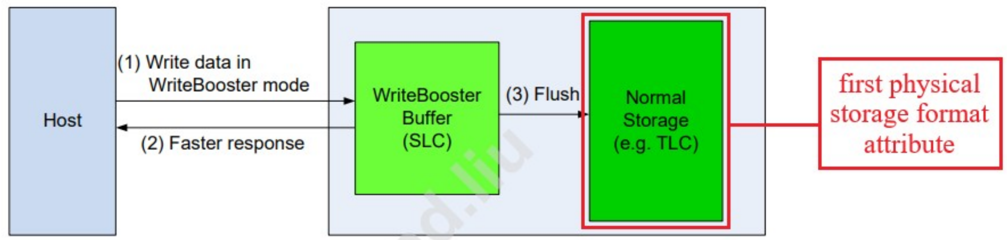
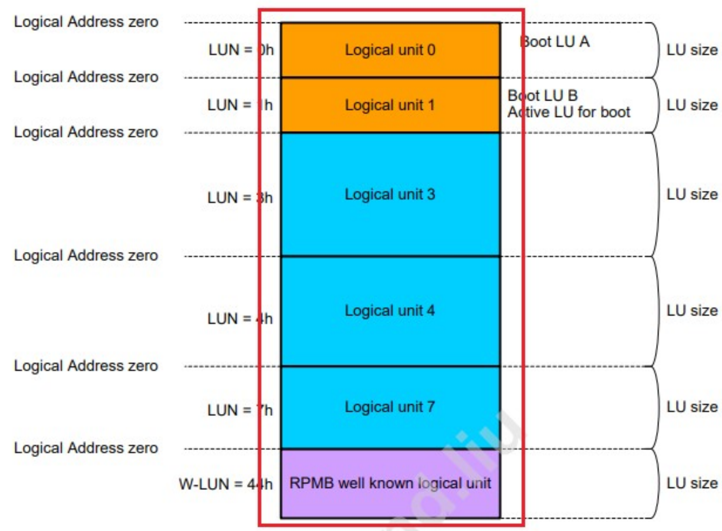


Figure 13.7 — Concept of WriteBooster feature

Source: JESD220E specification

5434 **13.2.2 Logical Unit features (cont'd)**



Source: JESD220E specification

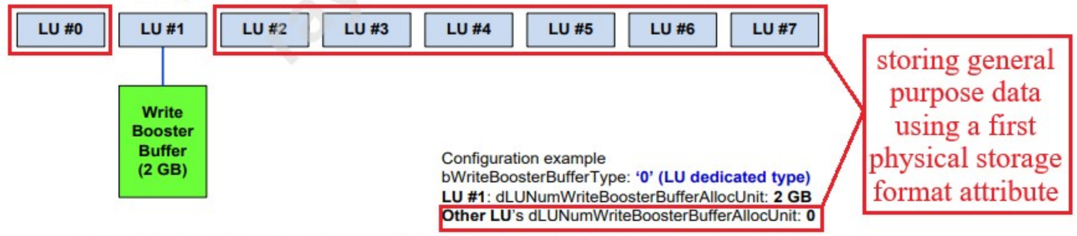
5500 **13.2.3 Logical Unit Configuration (cont'd)**

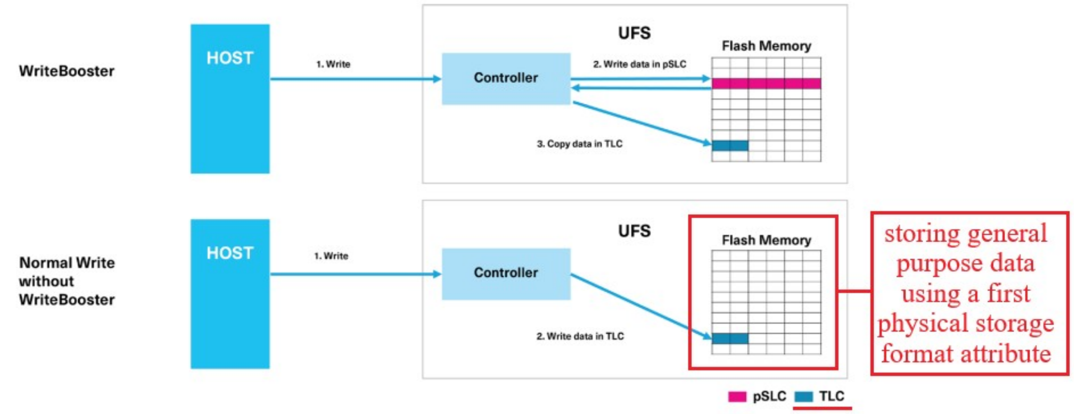
5501 Table 13.3 summarizes the configurable parameters per logical unit. See 14.1.4, Descriptor Definitions,
5502 for details about these parameters.

5503 **Table 13.3 — Logical unit configurable parameters**

Configurable parameters		Logical Unit
Name	**Description**	
bLUEnable	Logical Unit Enable	LU 0, …, Maximum LU specified by bMaxNumberLU
bBootLunID	Boot LUN ID	LU 0, …, Maximum LU specified by bMaxNumberLU
dLUNumWriteBoosterBufferAllocUnits	WriteBooster Buffer size for the corresponding Logical Unit	Valid only for LU 0, …, LU 7

Source: JESD220E specification

	LU dedicated buffer mode If the device supports the "LU dedicated buffer" mode, this mode is configured by setting bWriteBoosterBufferType to 00h. The logical unit WriteBooster Buffer size is configured by setting the dLUNumWriteBoosterBufferAllocUnits field of the related Unit Descriptor. Only a value greater than zero enables the WriteBooster feature in the logical unit. When bConfigDescrLock attribute is set to 01h, logical unit configuration can no longer be changed. The maximum number of supported WriteBooster Buffers is defined in the bDeviceMaxWriteBoosterLUs parameter of the Geometry Descriptor. bDeviceMaxWriteBoosterLUs is 01h, therefore the WriteBooster Buffer can be configured in only one logical unit. Figure 13.8 shows an example of device configuration with a 2 GB WriteBooster Buffer.  **Figure 13.8 — Example of "LU dedicated buffer" mode configuration** Source: JESD220E specification **13.4.17.3 Writing data to WriteBooster Buffer** If the fWriteBoosterEn flag is set to zero, data written to any logical unit is written in normal storage. If the fWriteBoosterEn flag is set to one and the device is configured in "shared buffer" mode, data written to any logical unit is written in the shared WriteBooster Buffer. If the fWriteBoosterEn flag is set to one and the device is configured in "LU dedicated buffer" mode, data written to the logical unit configured to use a dedicated buffer is written in the logical unit WriteBooster Buffer. Data written to any logical unit not configured to use a dedicated buffer is written in normal storage. Writes to the WriteBooster Buffer may decrease the lifetime and the availability of the WriteBooster Buffer. In the "LU dedicated buffer" mode, the device may write data from other LUs to the WriteBooster Buffer in case there are multiple pending commands while fWriteBoosterEn is set to one. Source: JESD220E specification

	In Figure 2 below, the top WriteBooster image shows how a pSLC buffer worsens the Write Amplification Factor[4] (WAF) since data is written to the pSLC buffer first, and then written to the TLC user space. The bottom image represents normal write operations without the WriteBooster feature enabled and shows that the pSLC buffer is not being used. For this operation, data is written directly to the TLC user space.  *Figure 2 depicts write operations with and without the WriteBooster Feature enabled* https://americas.kioxia.com/content/dam/kioxia/en-us/business/memory/mlc-nand/asset/KIOXIA_WriteBooster_Feature_Tech_Brief.pdf
storing streaming data on the storage medium using a second physical storage format attribute different than said first physical storage format attribute;	The accused product discloses storing streaming data (high speed low latency data) on the storage medium (e.g., NAND flash) using a second physical storage format attribute (e.g., memory blocks configured as single-bit per cell, SLC) different than said first physical storage format attribute (e.g., memory blocks configured as multi-bit per cell such as TLC, QLC or more). As shown below, the accused product is a storage system based on UFS 3.1. UFS 3.1 devices use multi-bit-per-cell technologies (TLC, QLC, and others) as the storage medium (NAND flash). Data from the host is written to the storage medium using Logical Units (LUs), each with memory blocks mapped to it. The UFS 3.1 specification includes a 'WriteBooster' feature, which creates an SLC buffer from TLC/QLC blocks. For time-critical and high-speed tasks, such as streaming or downloading data from a 5G connection, LUs mapped to the SLC buffer are used.

UFS part numbers and specifications

Part number	Capacity	Description	Package	Operating temperature
UFS32G-TXA7	32GB	UFS 2.1 G4 2L 153B 32GB	11.5x13x0.85	-25°C ~ +85°C
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UFS256-CY14	256GB	UFS 3.1 G4 4P TLC 153B 256GB	11x13x0.95	-25°C ~ +85°C

https://www.kingston.com/en/embedded/ufs-embedded-flash

How does 5G impact UFS (Universal Flash Storage)?

What is UFS Protocol? What is its connection with 5G?

The arrival of 5G is changing the way the smartphone is being used and leading the way to the next generation of mobile technology. The smartphone vendors are planning to offer seamless and immersive experiences on mobile devices. 5G offers ultra-fast transfers, low latency, and low power consumption on mobile devices. These high-speed data transfers mandate the need for high-speed storage interfaces such as UFS 4.0/3.0 on mobile devices.

streaming data

https://www.prodigytechno.com/how-does-5g-impact-ufs-universal-flash-storage

Prior to UFS 3.1, storage devices couldn't achieve the 500 MB/sec write performance needed for 5G. JEDEC added a feature called "write booster" where the host can tell the device "I want you to take a load of data and write it into a single-level cell (SLC) non-volatile cache to increase write speed." SLC has a higher threshold voltage than MLC and TLC in Figure 4. It's a new API just to enable 5G.

storing streaming data using a second physical storage format attribute

https://www.5gtechnologyworld.com/six-design-considerations-for-local-data-storage/

Write Booster:

UFS 3.1 introduces a feature called Write Booster, which uses a small portion of the storage as SLC (Single Level Cell) NAND to speed up write operations. This is particularly useful for large file transfers or when you're downloading large apps or games.

storing streaming data using a second physical storage format attribute

https://www.blackview.hk/blog/tech-news/ufs-3-1-storage-speed

What is UFS 3.1 and how does it work?

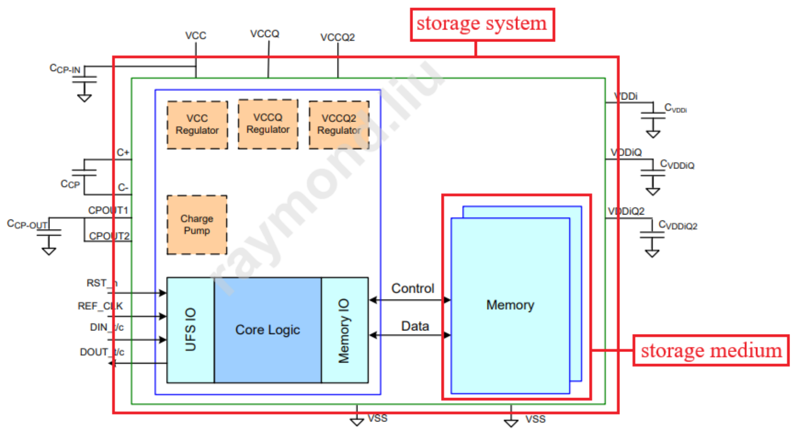
Author: icDirectory · Date: June 24, 2024 15:06:29

Universal Flash Storage (UFS) 3.1 is a high-performance storage technology designed for mobile devices, such as smartphones and tablets, but it can also be used in other applications like laptops, digital cameras, and automotive systems. UFS 3.1 builds upon the capabilities of its predecessor, UFS 3.0, offering improvements in speed, power efficiency, and overall performance. Here's a detailed look at what UFS 3.1 is, how it works, and the key features it brings to the table:

Architecture and Components

1. NAND Flash Memory:
- UFS 3.1 utilizes NAND flash memory, which is a type of non-volatile storage that retains data even when the device is powered off. NAND flash memory is known for its high density, fast read/write speeds, and durability.

https://www.icdirectory.com/blog/what-is-ufs-3-1-and-how-does-it-work-41004339.html



Source: JESD220E specification

UFS Logical Units

UFS flash device is composed of memory blocks that are mapped to different Logical Units (LUs). UFS device address space is organized in several memory areas configurable by the user. In particular, such memory areas are denoted as logical units and characterized by the fact that they have independent logical addressable spaces starting from the logical address zero. Thus, a logical unit (LU) is an externally addressable, independent, processing entity that processes SCSI tasks (commands) and performs task management functions. Each logical unit is independent of other logical units in a device

https://software-dl.ti.com/processor-sdk-linux/esd/AM65X/07_00_01_06/exports/docs/linux/Foundational_Components/Kernel/Kernel_Drivers/UFS.html

Kilobyte: 1024 or 2^{10} bytes.

Logical Unit: A logical unit is an internal entity of a bus device that performs a certain function or addresses a particular space or configuration within a bus device.

Source: JESD220E specification

13.4.17 WriteBooster

13.4.17.1 Overview

The write performance of TLC NAND is considerably lower than SLC NAND because the logically defined TLC bits require more programming steps and have higher error correction probability. To improve the write performance, part of the TLC NAND (normal storage) is configured as SLC NAND and used as write buffer, temporarily or permanently. Using SLC NAND as a WriteBooster Buffer enables the write request to be processed with lower latency and improves the overall write performance. Some portions of TLC NAND allocated for the user area are assigned as the WriteBooster Buffer. The data written in the WriteBooster Buffer can be flushed into TLC NAND storage by an explicit host command or implicitly while in hibernate (HIBERN8) state. Technologies other than TLC and SLC NAND may be used as normal storage and WriteBooster Buffer.

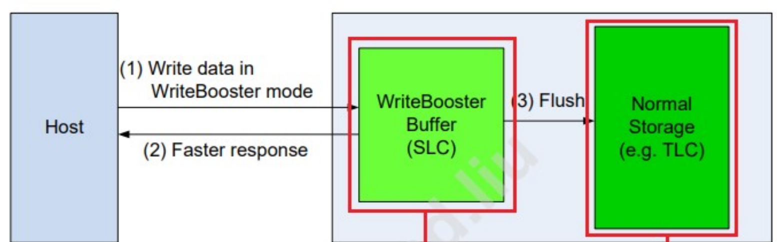


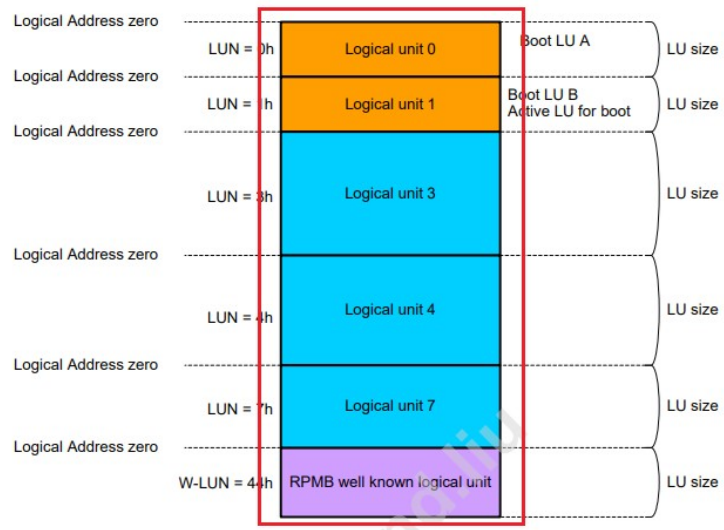
Figure 13.7 — Concept of WriteBooster feature

second physical storage format attribute

first physical storage format attribute

Source: JESD220E specification

5434 **13.2.2 Logical Unit features (cont'd)**



Source: JESD220E specification

5500 **13.2.3 Logical Unit Configuration (cont'd)**

5501 Table 13.3 summarizes the configurable parameters per logical unit. See 14.1.4, Descriptor Definitions,
5502 for details about these parameters.

5503 **Table 13.3 — Logical unit configurable parameters**

Configurable parameters		Logical Unit
Name	**Description**	
bLUEnable	Logical Unit Enable	LU 0, …, Maximum LU specified by bMaxNumberLU
bBootLunID	Boot LUN ID	LU 0, …, Maximum LU specified by bMaxNumberLU
dLUNumWriteBoosterBufferAllocUnits	WriteBooster Buffer size for the corresponding Logical Unit	Valid only for LU 0, …, LU 7

Source: JESD220E specification

GEOMETRY DESCRIPTOR				
Offset	Size	Name	Value	Description
54h	1	bWriteBoosterBufferCapAdjFac	Device specific	Capacity Adjustment Factor for the WriteBooster Buffer memory type. This value provides the LBA space reduction multiplication factor when WriteBooster Buffer is configured in user space reduction mode. Therefore, this parameter applies only if bWriteBoosterBufferPreserveUserSpaceEn is 00h. For "LU dedicated buffer" mode, the total user space is decreased by the following amount: bWriteBoosterBufferCapAdjFac * dLUNumWriteBoosterBufferAllocUnits * bAllocationUnitSize * dSegmentSize * 512 byte'. For "shared buffer" mode, the total user space is decreased by by the following amount: bWriteBoosterBufferCapAdjFac * dNumSharedWriteBoosterBufferAllocUnits * bAllocationUnitSize * dSegmentSize * 512 byte. The value of this parameter is 3 for TLC NAND when SLC mode is used as WriteBooster Buffer. 2 for MLC NAND.

Source: JESD220E specification

LU dedicated buffer mode

If the device supports the "LU dedicated buffer" mode, this mode is configured by setting bWriteBoosterBufferType to 00h. The logical unit WriteBooster Buffer size is configured by setting the dLUNumWriteBoosterBufferAllocUnits field of the related Unit Descriptor. Only a value greater than zero enables the WriteBooster feature in the logical unit. When bConfigDescrLock attribute is set to 01h, logical unit configuration can no longer be changed.

The maximum number of supported WriteBooster Buffers is defined in the bDeviceMaxWriteBoosterLUs parameter of the Geometry Descriptor. bDeviceMaxWriteBoosterLUs is 01h, therefore the WriteBooster Buffer can be configured in only one logical unit.

Figure 13.8 shows an example of device configuration with a 2 GB WriteBooster Buffer.

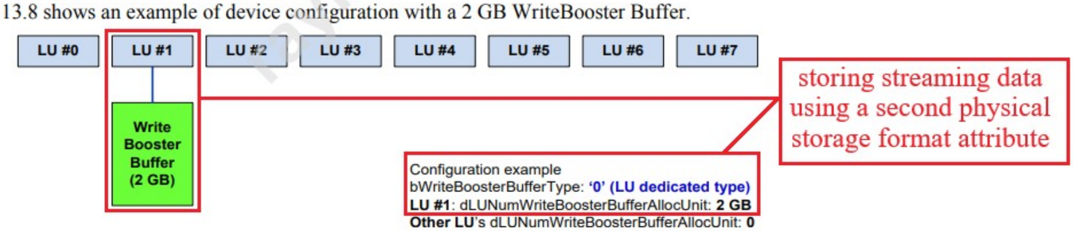


Figure 13.8 — Example of "LU dedicated buffer" mode configuration

Source: JESD220E specification

<table>
<tr>
<td></td>
<td>

13.4.17.3 Writing data to WriteBooster Buffer

If the fWriteBoosterEn flag is set to zero, data written to any logical unit is written in normal storage.

If the fWriteBoosterEn flag is set to one and the device is configured in "shared buffer" mode, data written to any logical unit is written in the shared WriteBooster Buffer.

If the fWriteBoosterEn flag is set to one and the device is configured in "LU dedicated buffer" mode, data written to the logical unit configured to use a dedicated buffer is written in the logical unit WriteBooster Buffer. Data written to any logical unit not configured to use a dedicated buffer is written in normal storage.

Writes to the WriteBooster Buffer may decrease the lifetime and the availability of the WriteBooster Buffer.

In the "LU dedicated buffer" mode, the device may write data from other LUs to the WriteBooster Buffer in case there are multiple pending commands while fWriteBoosterEn is set to one.

Source: JESD220E specification

In Figure 2 below, the top WriteBooster image shows how a pSLC buffer worsens the Write Amplification Factor[4] (WAF) since data is written to the pSLC buffer first, and then written to the TLC user space. The bottom image represents normal write operations without the WriteBooster feature enabled and shows that the pSLC buffer is not being used. For this operation, data is written directly to the TLC user space.

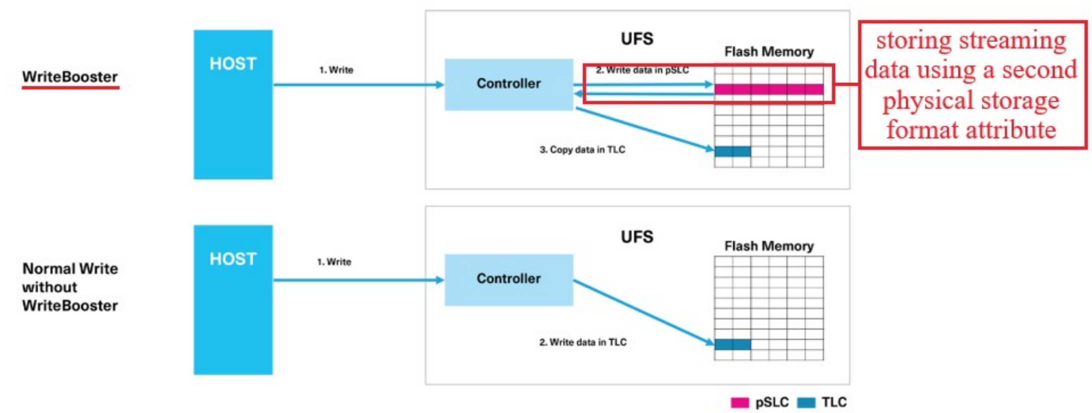


Figure 2 depicts write operations with and without the WriteBooster Feature enabled

https://americas.kioxia.com/content/dam/kioxia/en-us/business/memory/mlc-nand/asset/KIOXIA_WriteBooster_Feature_Tech_Brief.pdf

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<tr>
<td>said first and second</td>
<td>The accused product discloses storing data using first and second physical</td>
</tr>
</table>

<table>
<tr>
<td>physical storage attributes being associated with differing storage qualities selected from the group consisting of: resilience to errors, data integrity, storage density, and storage capacity.</td>
<td>storage attributes (e.g., memory blocks configured as single-bit per cell, SLC and multi-bit per cell such as TLC, QLC or more), said first and second physical storage attributes (e.g., memory blocks configured as single-bit per cell, SLC and multi-bit per cell such as TLC, QLC or more) being associated with differing storage qualities selected from the group consisting of: resilience to errors, data integrity, storage density, and storage capacity.

As shown below, the accused product is a storage system based on UFS 3.1. UFS 3.1 devices use multi-bit-per-cell technologies (TLC, QLC, and others) as the storage medium (NAND flash). Data from the host is written to the storage medium using Logical Units (LUs), each having memory blocks mapped to it. The UFS 3.1 specification includes a 'WriteBooster' feature, which creates an SLC buffer from TLC/QLC blocks. For time-critical and high-speed tasks, such as streaming or downloading data from a 5G connection, LUs mapped to the SLC buffer are used, whereas for low-volume, non-critical operations, such as saving data in the background, LUs mapped to the TLC/QLC blocks are used.

Furthermore, the SLC and TLC/QLC blocks used to store different types of data differ in storage qualities such as speed, storage density, resilience to errors, endurance, and more. SLC blocks are much faster than TLC/QLC blocks and have higher resilience to errors. TLC/QLC blocks have triple or quadruple the storage density of SLC blocks. For the same price, TLC/QLC blocks provide more storage capacity compared to SLC blocks.

UFS part numbers and specifications
<table>
<tr><th>Part number</th><th>Capacity</th><th>Description</th><th>Package</th><th>Operating temperature</th></tr>
<tr><td>UFS32G-TXA7</td><td>32GB</td><td>UFS 2.1 G4 2L 153B 32GB</td><td>11.5x13x0.85</td><td>-25℃ ~ +85℃</td></tr>
<tr><td>UFS64G-TXA7</td><td>64GB</td><td>UFS 2.1 G4 2L 153B 64GB</td><td>11.5x13x0.85</td><td>-25℃ ~ +85℃</td></tr>
<tr><td>UFS256-CY14</td><td>256GB</td><td>UFS 3.1 G4 4P TLC 153B 256GB</td><td>11x13x0.95</td><td>-25℃ ~ +85℃</td></tr>
</table>
https://www.kingston.com/en/embedded/ufs-embedded-flash</td>
</tr>
</table>

What is UFS 3.1 and how does it work?

Author: icDirectory · Date: June 24, 2024 15:06:29

Universal Flash Storage (UFS) 3.1 is a high-performance storage technology designed for mobile devices, such as smartphones and tablets, but it can also be used in other applications like laptops, digital cameras, and automotive systems. UFS 3.1 builds upon the capabilities of its predecessor, UFS 3.0, offering improvements in speed, power efficiency, and overall performance. Here's a detailed look at what UFS 3.1 is, how it works, and the key features it brings to the table:

Architecture and Components

1. NAND Flash Memory:
- UFS 3.1 utilizes NAND flash memory, which is a type of non-volatile storage that retains data even when the device is powered off. NAND flash memory is known for its high density, fast read/write speeds, and durability.

https://www.icdirectory.com/blog/what-is-ufs-3-1-and-how-does-it-work-41004339.html

13.4.17 WriteBooster

13.4.17.1 Overview

The write performance of TLC NAND is considerably lower than SLC NAND because the logically defined TLC bits require more programming steps and have higher error correction probability. To improve the write performance, part of the TLC NAND (normal storage) is configured as SLC NAND and used as write buffer, temporarily or permanently. Using SLC NAND as a WriteBooster Buffer enables the write request to be processed with lower latency and improves the overall write performance. Some portions of TLC NAND allocated for the user area are assigned as the WriteBooster Buffer. The data written in the WriteBooster Buffer can be flushed into TLC NAND storage by an explicit host command or implicitly while in hibernate (HIBERN8) state. Technologies other than TLC and SLC NAND may be used as normal storage and WriteBooster Buffer.

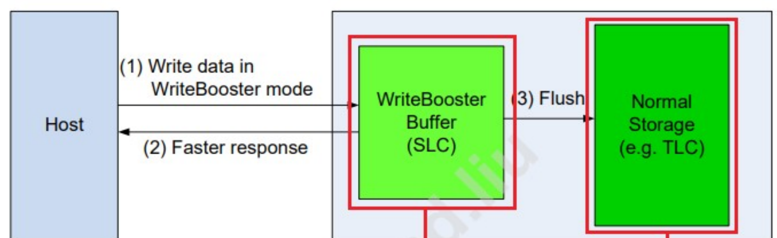


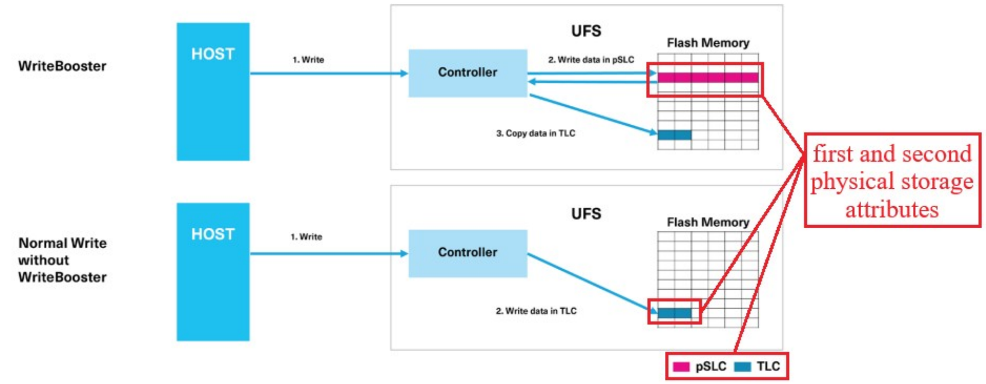
Figure 13.7 — Concept of WriteBooster feature

second physical storage format attribute

first physical storage format attribute

Source: JESD220E specification

In Figure 2 below, the top WriteBooster image shows how a pSLC buffer worsens the Write Amplification Factor[4] (WAF) since data is written to the pSLC buffer first, and then written to the TLC user space. The bottom image represents normal write operations without the WriteBooster feature enabled and shows that the pSLC buffer is not being used. For this operation, data is written directly to the TLC user space.



https://americas.kioxia.com/content/dam/kioxia/en-us/business/memory/mlc-nand/asset/KIOXIA_WriteBooster_Feature_Tech_Brief.pdf

GEOMETRY DESCRIPTOR				
Offset	**Size**	**Name**	**Value**	**Description**
54h	1	bWriteBoosterBufferCapAdjFac	Device specific	Capacity Adjustment Factor for the WriteBooster Buffer memory type. This value provides the LBA space reduction multiplication factor when WriteBooster Buffer is configured in user space reduction mode. Therefore, this parameter applies only if bWriteBoosterBufferPreserveUserSpaceEn is 00h. For "LU dedicated buffer" mode, the total user space is decreased by the following amount: bWriteBoosterBufferCapAdjFac * dLUNumWriteBoosterBufferAllocUnits * bAllocationUnitSize * dSegmentSize * 512 byte'. For "shared buffer" mode, the total user space is decreased by by the following amount: bWriteBoosterBufferCapAdjFac * dNumSharedWriteBoosterBufferAllocUnits * bAllocationUnitSize * dSegmentSize * 512 byte. The value of this parameter is 3 for TLC NAND when SLC mode is used as WriteBooster Buffer. 2 for MLC NAND.

Source: JESD220E specification

https://www.techtarget.com/searchstorage/tip/The-truth-about-SLC-vs-MLC